APPENDIX B

TYPICAL CE BLASTING SPECIFICATIONS

1-1. Introduction. Paragraphs 1-2, 1-3 and 1-4 below are examples of typical actual construction specifications on blasting for large structures and roadcuts. Only the portions pertaining to blasting have been extracted. The fourth example (par. 1-5) specified seismic monitoring for vibration and damage control at a large quarry.

1-2. Blasting Specifications for Spillway and Intake Structure (in Andesite and Tuff Breccia), Blue River Dam.

SECTION 3. EXCAVATION

3-04. EXCAVATION FEATURES.

j. Excavation, Intake Structure. - (1) A prism of rock not less than 15 feet wide adjacent to the walls of the intake structure above elevation 1150 shall be drilled and blasted in lifts not exceeding 20 feet in depth only after removal of the interior portion of the channel.

(2) A prism of rock not less than 15 feet wide adjacent to the face forming the tunnel portal shall be excavated only after removal of the interior portion of the channel. Above elevation 1160 the blasting lifts shall not exceed 20 feet in depth. Below elevation 1160 the blasting lifts shall not exceed 10 feet in depth. All blast holes in the rock prism adjacent to the portal slope shall be deck loaded or loaded with explosives on a detonating cord and delayed in a pattern and sequence that will prevent back-pressure and damage to final faces. Presplit blasting shall be used along the portal face down to elevation 1160. Below elevation 1160 "Line Drilling" shall be used along the portal face and along each end of the rock prism adjacent to the portal slope. "Line Holes" shall not be more than one hole diameter apart and shall not be loaded with explosives.

k. Excavation, Spillway Channel. - The 20-foot-wide zone of rock adjacent to each of the two channel walls shall be excavated only after removal of the interior portion of the channel excavation. In addition to presplit blastholes along the final slopes, the width of lifts and the pattern and

sequence of detonating blast holes shall be such that will prevent back-pressures and damage to final faces and configuration.

3-05. EXPLOSIVES. - a. Safety. - In addition to full compliance with Section XXII, Blasting, of General Safety Requirements, EM 385-1-1, dated 13 March 1958.†

b. Storage. - The Contractor shall submit to the Contracting Officer, for approval, drawings showing the location, access to and type of construction of the proposed storage magazine for explosives, and cap house. The explosives storage magazine and other facilities may be located on Government lands if satisfactory locations can be found and are approved by the Contracting Officer; or the Contractor, at his option, through private negotiations, may locate explosive magazines outside Government lands. The Contractor shall provide and maintain access to the explosive storage areas at his own expense.

3-06. DRILLING AND BLASTING. - a. General. - The drilling and blasting program and methods shall be those necessary to accomplish the excavation shown on the contract drawings in accordance with the procedure specified herein. Under no circumstances shall blasting be performed within 100 feet of concrete which has been placed less than seven days. Blasting within 100 feet of concrete older than seven days will be permitted only if approved by the Contracting Officer. A 50-watt, remote-controlled radio transmitting tower owned and operated by the Forest Service is located near the auxiliary dam as indicated on the drawings. Necessary precautions to avoid a premature blast due to operation of the transmitter shall be taken by the Contractor.

b. Blasting. - Prior to drilling for each blast, unless excepted by the Contracting Officer, the Contractor shall submit on an approved form the pertinent data on the location, depth and area of the blast; diameter, spacing, depth, overdepth, pattern and inclination of blast holes; the type, strength, amount, distribution and powder factor for the explosives used per hole and per

† The manual has subsequently been revised and issued 1 Mar 1967.

blast; the sequence and pattern of delays, and description and purpose of special methods. The loading of holes shall be done in the presence of a Government inspector. Acceptance by the Contracting Officer of blasting data will not relieve the Contractor of his responsibility to produce satisfactory results as set forth in these specifications. Drilling and blasting shall be done only to the depth, amount and at such locations, with explosives of such quantity, distribution and density that will not produce unsafe or damaged rock surfaces or damage rock beyond the prescribed excavation limits. Excavation for this contract has rock with vertical and lateral variations in hardness and texture containing open and oxidized seams, shear planes, joints and faults. As excavation operations progress, the drilling and blasting procedures shall be determined only by satisfactory results achieved, and approved by the Contracting Officer. When a drilling and blasting program results in damage to the excavation, the Contractor will be required to devise and employ methods which will prevent such damage. The revision may include special methods such as presplit and zone blasting, shallow lifts, reduction in size of individual blasts, small diameter blast holes, closely spaced blast holes, reduction of explosives, greater distribution of explosives by use of decking and primacord or variation in density of explosives.

c. Presplit Blasting. - (1) General. - The presplit method of blasting is defined as the use of an optimum quantity of explosives, distributed along primacord the full hole depth and detonated so as to produce an open shear plane between closely spaced blast holes prior to the adjacent primary blasting. This method shall be used for all faces or slopes steeper than 1 on 1.

(2) Open Cut Excavation. - Presplit blast holes shall be detonated prior to drilling and blasting of the adjacent rock. Test blasts may be used in the areas of varying slope and rock conditions. However, the spacing of loaded presplit blast holes shall not exceed 24 inches center to center, and may be as close as 12 inches. Blast holes in areas of total confinement may be drilled to the full depth of the excavation; however, in some areas with open faces the depth of blast holes may be limited and will not exceed the horizontal burden. The hole diameter shall be at least two times the diameter of the explosive cartridge. The amount

of explosives in blast holes having a slope flatter than one on one-third shall be reduced progressively with the flattening of slope. The depth of stemming above the explosive will be kept to a minimum and shall not exceed one-fourth of blast hole depth. Stemming may be required between each explosive charge in areas where rock contains open, weathered, or clay-filled seams, joints or faults.

d. Structures. - Excavation of slopes, faces and shapes in the foundation for structures may necessitate, in addition to presplit blasting, the use of full hole decking, limitation on the depth of blast holes, and a limitation on the width of blast area adjacent to final surfaces to prevent structural damage to rock beyond the excavation lines. The method and type of blast hole decking and hole spacing will be determined by results which are satisfactory to the Contracting Officer.

e. Berms, Benches, Faces and Structural Forms. - Where a berm, bench or other horizontal surface superimposes a vertical or sloped surface, excavation to line and grade of the horizontal surface shall be completed prior to starting excavation of the vertical or sloped surfaces in order to prevent loss of the berm shoulder or damage to the underlying rock face. Blast holes shall not be drilled to a depth greater than 2 feet below the design grade of a berm. Drilling and blasting lift depths in confined shapes or features shall be limited from one-half to two-thirds the excavation width unless otherwise approved by the Contracting Officer.

f. Final Grades and Excavation Lines. - When excavation has progressed to within 15 feet of the final grade or lines of required excavation against which concrete is to be placed, drilling and blasting shall be limited to two-thirds of the remaining depth of excavation except that when 5 feet or less of rock remains to be excavated, blasting may be permitted to final grade if it can be demonstrated that no damage will result to the foundation. Blast holes larger than 3-1/2 inches in diameter shall not be drilled closer than 5 feet to a horizontal or near horizontal grade or within 15 feet of a vertical or near vertical face. Whenever, in the opinion of the Contracting Officer, further blasting may injure the rock upon or against which concrete is to be placed, the use of explosives shall be discontinued and the excavation

shall be completed by hand methods and/or pneumatic tools, by wedging, barring, picking or other approved methods exclusive of explosives.

1-3. Blasting Specification for Structure Area (in Limestone), Stockton Dam.

SECTION B2. EXCAVATION

B2-05. Spillway-Powerhouse Area Excavation. a. General. (1) Spillway-powerhouse area is identified as the areas which are prepared for the concrete structure and includes the approach and outlet channel.

(2) Structure area is identified as that portion of the spillway-powerhouse area from dam station 99+84 to dam station 106+48, range 0+90 upstream to range 4+12 downstream.

B2-08. Lines, Grades, and Tolerances. a. General. Unless otherwise specified, all excavation shall be completed to the lines and grades shown on the drawings.

b. "A" and "B" lines as shown on the drawings indicate the maximum and minimum limits for "Bearing Surfaces" and "Special Surfaces." No material will be permitted to remain inside the "A" lines.

c. Tolerances. (1) "Special Surfaces" are presplit rock surfaces (except 1 on 1.5 spillway apron slope) against which concrete is to be placed. The tolerances are the "A" lines to "B" lines.

(2) "Bearing Surfaces" are all surfaces under concrete structures which are not defined as "Special Surfaces." Tolerances are the "A" lines to "B" lines.

(3) Presplit Surfaces (Other than "Special Surfaces"). Tolerances from the surfaces shown on the drawings shall not exceed three feet measured horizontally, however, the maximum horizontal tolerance between adjacent presplit holes shall not exceed twelve inches.

B2-09. Care of Water.

c. Structure Area. The ground-water level shall be lowered in advance of excavation to permit excavation in the dry and to minimize the water in the presplit blast holes and the presplit fracture. Not less than twenty days before the rock excavation reaches elevation 770, calyx holes 1, 2, and 3 shall be thoroughly cleaned out and dewatering started. The water level in the calyx holes shall be lowered to and maintained at a level within 5 feet above the bottom of the holes until excavation is completed. The Government reserves the right to use the calyx holes for observations. Calyx holes 1 and 3 shall be backfilled with lean concrete as directed and calyx hole 2 shall be treated as shown on the drawings. Lean concrete is specified in Division A, section CONCRETE, GENERAL.

d. The Spillway-Powerhouse Area. Excavation shall be performed in the dry.

B2-10. Blasting. a. General. All blasting in the spillway-powerhouse area outside of the structure area and in the quarry for rockfill shall be designed to produce the maximum amount of material suitable for rockfill zones and to minimize the quantity of grizzly fines. No blasting shall be allowed within 100 feet of concrete or grout which has an age less than 7 days nor within 50 feet of any concrete or grout regardless of age. It was found in blasting for rockfill in quarry No. 2 during Stage I Construction that the use of low density powder produced the best results, as the quantity of grizzly fines was substantially reduced. As "Special Surfaces," "Bearing Surfaces," other presplit surfaces, and other final surfaces are approached, blasting shall be carefully controlled to avoid damage to these surfaces. Initial drilling and blasting in any area or type of rock shall be limited to a maximum production of 2,000 cubic yards per shot until the method is proven to produce the specified results. Subsequent drilling and blasting in required excavations shall be limited to a maximum production of 6,000 cubic yards per shot in the Spillway Powerhouse Structure Area. In "Spillway-Powerhouse Excavation - Rock" and "Quarry Excavation-Rock" the size of the shot may be increased in increments up to 3,000 cu. yds. provided the fragmentation and clay content of the excavated material is and continues to be satisfactory. The maximum

size of production shall be limited to 20,000 cu. yds. per shot. All muck in front of any face being shot including the structure area shall have been removed before the round is fired. The use of millisecond delays is not initially restricted; however, should proper fragmentation not be obtained, or if overfragmentation produces excessive fines or incipient fractures in the rock to be used for "Rock Zone 2" and "Rock Zone 3," the Contracting Officer reserves the right to prohibit the use of millisecond delays and to require the use of regular delays. Drilling equipment must be capable of efficiently drilling blast holes from 2 inches to 5 inches in diameter. The manner in which the rock breaks as excavation progresses will be observed and if the specified results are not obtained, the Contractor will be required to revise his operation as necessary. The blasting operation shall not be revised without the prior approval of the Contracting Officer. The Contractor shall keep records of each blasting shot (round) including the following information: date, station and range, lift, number of holes, hole size, consecutive shot number, spacing, and depth; kind of explosive, quantity and method of loading and firing; delays; fragmentation range, and percent of grizzly fines. A copy of the records shall be furnished the Contracting Officer after each round.

b. Structures. In the structure area blasting of the 20-foot wide protective bench and the lift immediately above the bearing surface as shown on the drawings, shall be accomplished using blast holes (inclined with the bottom pointing 20° to 30° from the vertical in a downstream direction). No holes shall be closer than four feet to adjacent "Special Surfaces." A slow velocity powder in the range of 5,500 feet per second shall be used in the angle holes. Bolting of "Special Surfaces" and anchoring is specified in Division B, section ROCK BOLTS, ANCHOR BARS, AND DRAPED FENCING.

c. Presplitting. All rock surfaces 1 on 1.25 or steeper and the 1 on 1.5 spillway apron slope shall be presplit. All rock surface slopes 1 on 3/4 or steeper shall be presplit prior to the time that horizontally adjacent material within 50 feet is drilled for blasting. Spillway apron shall be presplit lift by lift whenever the distance measured at the bottom of the lift is approximately 50 feet horizontal distance from the final surface. Depth of presplitting shall be limited to 33 feet on "Special Surfaces" elsewhere to

depths that Contractor demonstrates that tolerances can be maintained. Presplit surfaces shall be developed to at least three feet below the floor of a bench before the bench is blasted, except that the bottom bench shall be presplit to grade. General method of presplitting consists of drilling a line of holes spaced 24 inches (48 inches for "Spillway - Powerhouse Excavation - Rock") apart in the prescribed plane, loading all of these holes with an optimum amount of Trimtex or approved equal explosive, and detonating with Primacord or an approved equal detonating fuse. Results will be judged by the condition of the finished surface on which shall remain at least 70% of the length of casts for each of the presplit drill holes. No presplitting shall be done in the structure area until it has been demonstrated elsewhere that the techniques proposed obtain the specified results. Outside the structure area presplit lines shall be limited to 100 feet in length for each of the various slopes until it has been demonstrated that the technique produces the specified results.

B2-11. Excavation - Structure Area. a. Sequence of Excavation. Excavation shall be carried out in lifts as indicated on the drawings, and shall proceed in an upstream direction. A blasted "V" notch or stress relief slot as shown on the drawings shall be completed for each lift before drilling for primary blasting is done. Once a lift is started, it shall be carried to its final surface over its entire area before starting the next lift. Since the preservation of horizontal and vertical corners is critical, the presplitting of the protective bench shall be coordinated with the preset bolting as shown on the drawings and specified in Division B, section ROCK BOLTS, ANCHOR BARS, AND DRAPED FENCING. The 20-foot wide protective bench shall be shot after the muck from the adjacent primary blast has been removed. Rock bolting (other than preset bolts) as specified, and indicated on the drawings shall be completed within 24 hours after the protective bench is blasted.

b. Overexcavation and Backfill. Overexcavation because of a weakness inherent in the natural undisturbed structure of the bedrock shall be performed as directed, and the theoretical lines and grades will be adjusted accordingly. Material outside the excavation limits which are disturbed due to the fault or negligence of the Contractor or due to his failure to exercise sound engineering or

construction practices, shall be either replaced by him with suitable materials (earth or concrete), or bolted, or both as directed, at no cost to the Government.

1-4. Blasting Specifications for Roadcuts (in Basalt), Foster Regulating Reservoir.

3-04. EXPLOSIVES. - General. - In addition to full compliance with Section XXII, Blasting, of General Safety Requirements, EM 385-1-1, dated 13 March 1958. The Contractor shall submit to the Contracting Officer, for approval, drawings showing the location, access thereto and type of construction of the proposed storage magazine for explosives, cap house and "make up shack." The explosives storage magazine and other facilities may be located on Government lands if satisfactory locations can be found and are approved by the Contracting Officer; or the Contractor, at his option, through private negotiations, may locate explosive magazines outside Government lands. The Contractor shall provide and maintain access to the explosive storage areas at his own expense. In the use of explosives, the Contractor shall exercise the utmost care not to endanger life or property. The Contractor shall use methods and programs which will prevent damage to adjacent landscape features and which will minimize scattering of rock, stumps or other debris outside the finished roadway slopes. The Contractor will be responsible for any and all damage and/or injury resulting from the use of explosives.

b. Blasting. -

(1) The drilling and blasting methods and program shall be those necessary to accomplish the excavation shown on the contract drawings in accordance with the procedures specified herein. Explosives shall not be used as a primary means of transporting material outside the excavated prism.

(2) Prior to drilling for each blast, unless excepted by the Contracting Officer, the Contractor shall submit on an approved form a plan showing the location, size, spacing and depth of holes, blast hole loading, sequence and pattern of delays and special methods. Acceptance by the Contracting Officer of the blasting data will not relieve the Contractor of his responsibility to produce safe and satisfactory results as set forth by these specifications.

(3) Excavation for this contract has rock with vertical and lateral variations in hardness and texture, containing open and weathered seams, shear planes, joints and faults.

(4) Drilling and blasting shall be done only to the depth, amount and extent and with explosives of such quality, quantity and in such location that will neither disrupt nor damage the rock forming the prescribed limits of the excavation. When in the opinion of the Contracting Officer, damage is being done to the rock outside of the limits of the excavation, it will be the Contractor's responsibility to determine and use drilling and blasting methods that will produce the specified results regardless of the rock conditions encountered. Presplit Blasting shall be used to produce all slopes in rock excavation not ripped and which are more than 10 feet deep. The presplit method of blasting is defined as the use of an optimum quantity of explosives distributed along a detonating cord the depth of the blast hole so as to produce an open shear plane between closely spaced blast holes prior to blasting the adjacent rock. This method shall be used on all slopes steeper than 1 on 1 and shall be used the full depth of the rock excavation. Test blasting may be used in areas of varying slope and rock conditions. The presplit blast hole diameter shall be at least two times the diameter of the explosive cartridge. The holes shall be drilled parallel to the slope of the designed excavation and shall have a spacing not to exceed 30 inches but may be as close as 24 inches. Center to center holes in areas of total confinement may be drilled to the full depth of the excavation, however, in areas with open faces the depth of blast holes may be limited and will not exceed the horizontal burden. The blasting shall be accomplished by loading the holes with string charges of 40 percent gelatin dynamite attached to a detonating cord, so that all charges shall be uniformly spaced throughout the length of the hole.

Charges will not exceed 1/4 pound of dynamite per linear foot of depth. In addition, one pound of dynamite shall be concentrated at the bottom of the hole. The amount of explosives in blast holes having a slope flatter than one on one-half will be reduced progressively with the flattening of slope. Holes shall be stemmed with coarse sand or free-running gravelly sand having a maximum size of 3/8-inch. The depth of stemming shall be kept to a minimum and shall not exceed

one-fourth the blast hole depth. Stemming may be required between each explosive charge in areas where the rock contains open seams, joints or faults. Pre-split blast holes shall be detonated prior to drilling and blasting the adjacent rock except when conditions will not permit this method or when it can be demonstrated to the satisfaction of the Contracting Officer that in special cases a millisecond delay system will produce acceptable rock surfaces.

1-5. Seismic Monitoring Specifications, Milton Freewater Quarry.

3-03. BLASTING FOR QUARRY OPERATIONS.

a. General: All blasting operations shall be performed in accordance with the applicable provisions of Corps of Engineers Manual EM 385-1-1 dated 13 March 1958, entitled "General Safety Requirements" and supplemented by North Pacific Division Supplement, dated 15 July 1960. The Contractor shall furnish to the Contracting Officer prior to each blast a plan of all blast holes showing pattern and depth of drilling, type of explosive used, loading pattern, and sequence of firing. This plan shall show all holes, charges and existing quarry face relative to quarry boundaries by dimensions and elevations in feet. The drilling and blasting plan is for record purposes only, and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. If the Contractor selects and operates a quarry within one mile of any residence, building or bridge subject to vibration damage by blasting, the Contractor's blasting operations shall be subject to the requirements of paragraphs 3-03 b. and 3-03 c., below.

b. Monitoring: All blasting for quarry operations that are within one mile of any residence, bridge, or building shall be monitored for each blast. No separate payment will be made for blasting or monitoring blasts in the riprap quarry, and all costs thereof shall be incidental to and included in the applicable Item No. 7, "Riprap, Class I," Item No. 8, "Riprap, Class II," or Item No. 9, "Riprap, Class III." For the initial blast of the quarry, the quantity of explosive shall be limited to an amount which will not cause damage to buildings, bridges, or private property in the area. When ground characteristics for any specified

blasting location have been determined from the initial blast by instrumentation, the allowable quantity-distance relations between the amount of explosives used and the distance from the blast site shall be determined from the accepted results of instrumentation at the given operation for the various weights of explosives. The vibration measurements at the nearest building or dwelling shall not exceed a total Energy Ratio of 1.0. Recordings shall be taken at all of the most critical locations. The Energy Ratio in a single direction shall be calculated by the following formula:

$$E.R. = (3.29\ FA)^2$$

where F = frequency in cycles per second

A = amplitude in inches

Total Energy Ratio is defined as arithmetical sum of Energy Ratios in three mutually perpendicular planes of motion. Reference: Safety Regulation No. 23, dated 20 August 1965, State of New Jersey, Department of Labor and Industry, Trenton, New Jersey.

c. Seismograph: The Contractor shall have a minimum of two approved seismograph instruments for monitoring blasting operations (see exception, paragraph 3-03a). Additional instruments will be required if found necessary. Locations of instruments shall be subject to the approval of the Contracting Officer. Seismographs for monitoring of quarry blasting shall be placed at opposite locations. Each seismograph instrument shall be capable of recording photographically all three components of ground motion. The recorded data shall include for each shot:

(1) Identification of instrument used.

(2) Name of qualified observer.

(3) Name of qualified interpreter.

(4) Distance and direction of recording station from area of detonation.

(5) Type of ground at recording station.

(6) Maximum amplitudes for all components, as well as resultant for all recorded frequencies of vibrations.

(7) Duration of motion in excess of one-one thousandth of an inch.

(8) Frequency of ground motion in cycles per second.

(9) Maximum energy ratio.

(10) A copy of photographic records of seismograph readings, dated.

(11) Recorded data from each blast, including the computed energy ratio shall be furnished to the Contracting Officer prior to the next succeeding blast.